U. S. DEPARTMENT OF COMMERCE

BUILDING MATERIALS AND STRUCTURES

REPORT BMS46

Structural Properties of "Scot-Bilt" Prefabricated Sheet-Steel Constructions for Walls, Floors, and Roofs

Sponsored by
The Globe-Wernicke Co.

by

HERBERT L. WHITTEMORE,
AMBROSE H. STANG, *and*
VINCENT B. PHELAN

NATIONAL
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by HERBERT L. WHITTEMORE, AMBROSE H. STANG, *and* VINCENT B. PHELAN

ISSUED MAY 23, 1940

The National Bureau of Standards is a fact-finding organization; it does not "approve" any particular material or method of construction. The technical findings in this series of reports are to be construed accordingly.

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Foreword

This report is one of a series issued by the National Bureau of Standards on the structural properties of constructions intended for low-cost houses and apartments. These constructions were sponsored by organizations within the building industry advocating and promoting their use. The sponsor built and submitted the specimens described in this report for participation in the program outlined in BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions. The sponsor, therefore, is responsible for the design of the constructions and the description of materials and methods used in their fabrication. The Bureau is responsible for the method of testing and for the test results.

This report covers only the load-deformation relations and strength of the structural elements of a house when subjected to compressive, transverse, concentrated, impact, and racking loads by standardized methods simulating the loads to which the element would be subjected in actual service. Later, it may be feasible to determine the heat transmission at ordinary temperatures and the fire resistance of these same constructions.

The Forest Products Laboratory, Forest Service, United States Department of Agriculture, collaborated in the tests of those constructions which had wood structural members.

The National Bureau of Standards does not "approve" a construction, nor does it express an opinion as to the merits of a construction, for the reasons given in reports BMS1 and BMS2. The technical facts presented in this series provide the basic data from which architects and engineers can determine whether a construction meets desired performance requirements.

Lyman J. Briggs, *Director.*

Structural Properties of "Scot-Bilt" Prefabricated Sheet-Steel Constructions for Walls, Floors, and Roofs Sponsored by The Globe-Wernicke Co.

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ABSTRACT

For the program on the determination of the structural properties of low-cost house constructions The Globe-Wernicke Co. submitted 27 specimens representing their "Scot-Bilt" prefabricated sheet-steel wall, floor, and roof constructions.

The wall specimens were subjected to compressive, transverse, concentrated, impact, and racking loads; the floor specimens to transverse, concentrated, and impact loads; and the roof specimens to transverse and concentrated loads. The transverse, concentrated, and impact loads were applied to both faces of the wall specimens. The loads simulated the loads to which the elements of a house are subjected in actual service.

The deformation under load and the set after the load was removed were measured for uniform increments of load. The results are presented in graphs and in tables.

I. INTRODUCTION

To provide technical facts on the performance of constructions which might be used in low-cost houses, to discover promising new constructions, and ultimately to determine the properties necessary for acceptable performance in actual service, the National Bureau of Standards has invited the cooperation of the building industry in a program of research on building materials and structures suitable for low-cost houses and apartments. The objectives of this program are described in report BMS1, Research on Building Materials and Structures for Use in Low-Cost Housing, and that part of the program relating to structural properties in report

BMS2, Methods of Determining the Structural Properties of Low-Cost House Constructions.

Masonry constructions and wood constructions of types which have been extensively used in this country for houses were included in the program because their behavior under widely different service conditions is known to builders and the public. The reports on these constructions are BMS5, Structural Properties of Six Masonry Wall Constructions, and BMS25, Structural Properties of Conventional Wood-Frame Constructions for Walls, Partitions, Floors, and Roofs. The masonry specimens were built by the Masonry Construction Section of this Bureau, and the wood-frame specimens were built and tested by the Forest Products Laboratory at Madison, Wis.

The present report describes the structural properties of three elements of a house sponsored by one of the manufacturers in the building industry. Compressive, transverse, concentrated, impact, and racking loads were applied to the wall specimens, simulating the loads to which the elements of a house are subjected in actual service. Compressive loads on a wall are produced by the weight of the roof, second floor, and second-story walls, if any, by furniture and occupants, and by snow and wind loads on the roof. Transverse loads on a wall are produced by the wind, concentrated and impact loads by accidental contact with heavy objects, and racking loads by the action of the wind on adjoining walls. Transverse loads are applied to floors by furniture and occupants; concentrated loads by furniture, for example, the legs of a piano; and impact loads by objects falling on the floor or by persons jumping on the floor. Transverse loads are applied to roofs by wind and snow; concentrated loads by persons walking on the roof, and by tools and equipment when the roof is constructed and repaired.

The deflection and set under each increment of load were measured because, considered as a structure, the suitability of a construction depends not only on its resistance to deformation when loads are applied, but also on whether it returns to its original size and shape when the loads are removed.

II. SPONSOR AND PRODUCT

The specimens were submitted by The Globe-Wernicke Co., Cincinnati, Ohio, and represented prefabricated sheet-steel wall, floor, and roof constructions marketed under the trade name "Scot-Bilt," and consisting of channel-shaped panels locked together by special steel keys.

III. SPECIMENS AND TESTS

The specimens represented three elements of a house and were assigned the following symbols: Wall, *CQ;* floor, *CR;* roof, *CS.* The individual specimens were assigned the designations given in table 1.

TABLE 1.—*Specimen designations, wall CQ, floor CR, and roof CS*

Element	Specimen designation	Load	Load applied
Wall	*C1, C2, C3*	Compressive	Upper end.
Do	*T1, T2, T3*	Transverse	Inside face.
Do	*T4, T5, T6*	do	Outside face.
Do	*P1, P2, P3* [a]	Concentrated	Inside face.
Do	*P4, P5, P6* [a]	do	Outside face.
Do	*I1, I2, I3*	Impact	Inside face.
Do	*I4, I5, I6*	do	Outside face.
Do	*R1, R2, R3*	Racking	1 in. below upper end.
Floor	*T1, T2, T3*	Transverse	Upper face.
Do	*P1, P2, P3* [b]	Concentrated	Do.
Do	*I1, I2, I3*	Impact	Do.
Roof	*T1, T2, T3*	Transverse	Do.
Do	*P1, P2, P3* [a]	Concentrated	Do.

[a] The concentrated and transverse loads were applied to the same specimens. The transverse loads were applied first.

[b] The concentrated and impact loads were applied to the same specimens. The concentrated load was applied first.

Except as mentioned below, the specimens were tested in accordance with BMS2, which report also gives the requirements for the specimens and describes the presentation of the results of the tests, particularly the load-deformation graphs.

Because, under compressive load, there may be local shortening at the floor plate and top plate, the shortening of the entire specimen may not be proportional to the value obtained from compressometers attached to the specimen over only a portion of its height. Therefore, the shortenings and sets were measured with compressometers attached to the steel plates through which the load was applied, not attached to the specimen as described in BMS2.

The lateral deflections under compressive loads were measured with a deflectometer of

fixed gage length, which consisted of a light (duralumin) tubular frame having a leg at one end and a hinged plate at the other. The deflectometer was attached to the specimen by clamping the hinged plate near the upper end of either face. It was then in a vertical position, with a gage length (distance between the points of support) of 7 ft 6 in. A dial micrometer was attached to the frame at midlength, with the spindle in contact with the face of the wall specimen. The dial was graduated to 0.001 in., and readings were recorded to the nearest tenth of a division. There were two deflectometers on the specimen, one near each edge adjacent to the outer joints. This method of measurement was used instead of the taut-wire mirror-scale method described in BMS2.

For the transverse load the wall specimens were placed in a vertical position as for masonry walls and the lateral deflections measured in the same way as under compressive load.

The indentation under concentrated load and the set after the load was removed were measured, not the set only, as described in BMS2. The apparatus is shown in figure 1.

The load was applied to the steel disk, *A*, to which the crossbar, *B*, was rigidly attached. The load was measured by means of the dynamometer, *C*. Two stands, *D*, rested on the face of the specimen, each supporting a dial micrometer, *E*, the spindle of which was in contact with the crossbar about 8 in. from the disk. The micrometers were graduated to 0.001 in. and readings were recorded to the nearest division. The initial reading (average of the micrometer readings) was observed under the initial load, which included the weight of the disk and dynamometer. A load was applied to the disk, and the average of the micrometer readings minus the initial reading was taken as the depth of the indentation under load.

The deformations under racking load were measured with a right-angle deformeter, consisting of a steel channel and a steel angle braced to form a rigid connection. In use, the channel of the deformeter, supported by two steel plates, ½ in. thick and 4 in. square, rested along the top of the specimen, with the steel angle extending downward in the plane of the specimen. Two pins passed snugly through holes in the channel into the top of the specimen. A dial micrometer was attached to a steel block which was in contact with the edge of the specimen near the stop. The spindle of the micrometer was in contact with the steel angle of the deformeter. The gage length (distance from the top of the specimen to the center of the steel block) was 7 ft 11¼ in. The micrometer was graduated to 0.001 in. and readings were recorded to the nearest division. This deformeter was used instead of the taut-wire mirror-scale device described in BMS2.

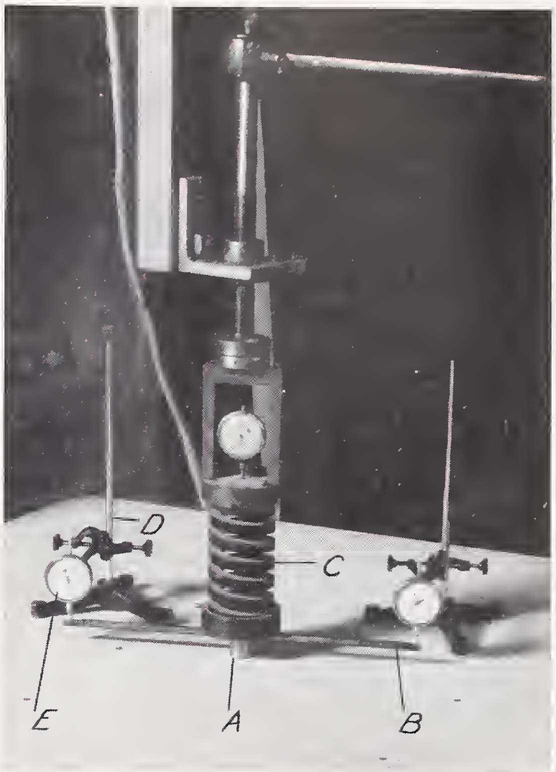


FIGURE 1.—*Apparatus for concentrated load test.*

A, disk; *B*, crossbar; *C*, spring dynamometer; *D*, stand; *E*, dial micrometer.

The tests were begun June 30, 1939, and completed July 13, 1939. The sponsor's representative witnessed the tests.

IV. MATERIALS

The information on the materials was obtained from the sponsor and from inspection of the specimens. The Forest Products Laboratory assisted by identifying the species of the wood in the nailing strips, subflooring, and finish flooring. The Engineering Mechanics Section of the National Bureau of Standards

determined the moisture content of the wood and the weight and strength of the gypsum wallboard.

1. Steel

Sheets.—Hot-rolled, annealed, and pickled. The specified chemical composition of the steel is given in table 2 and the mechanical properties in table 3. Carnegie-Illinois Steel Corporation.

TABLE 2.—*Specified chemical composition of the sheet steel*

Element	Content	
	Minimum	Maximum
	Percent	*Percent*
Carbon	----------	0.12
Manganese	0.20	.50
Phosphorus	----------	.05
Sulfur	----------	.04

TABLE 3.—*Mechanical properties of the sheet steel*

Yield point		Tensile strength		Elongation in 8 in.	
Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
lb/in.²	*lb/in.²*	*lb/in.²*	*lb/in.²*	*Percent*	*Percent*
24,000	34,000	37,000	50,000	17	22

Welds.—Electric spot welds, ¼-in. diam. They were made with a 30-kva welding machine, manually operated, manufactured by the Federal Machine & Welder Co. Before beginning production, weld specimens were made by welding two strips of steel and were tested either by wedging the strips apart with a cold chisel or by rotating the strips in opposite directions. The adjustment of the welding machine was considered satisfactory if not less than 98 percent of the specimens ruptured in the thinner sheet.

2. Wood

Nailing strips.—Identified as yellow poplar, *Liriodendron tulipifera.*

No. 1 common, 23/32 by 17/16 in., S4S (surfaced four sides); rabbeted along two edges ¼ in. wide by 3/16 in. deep, and grooved at midwidth 3/16 in. wide by 17/32 in. deep.

Subflooring.—Identified as southern yellow pine, *Pinus sp.*

No. 2 common, 25/32 in. thick by 5 3/16 in. face width (nominal 1 by 6 in.); dressed, tongue-and-grooved, and end-matched.

Finish flooring.—Identified as white oak, *Quercus sp.*

No. 1 common, 25/32 in. thick by 2¼ in. face width; dressed, tongue-and-grooved, and end-matched.

Spacer blocks.—Yellow poplar, No. 1 common, S2S; two sizes, 1 by 1 in. and 1⅜ by 2 in.

Edge strips.—Yellow poplar, No. 1 common, ⅞ by 2 in., S2S.

Moisture content.—The moisture content of the subflooring, determined for six pieces from each specimen, was 13 percent, based on the weight when dry; and the moisture content of the finish flooring, determined for six pieces from each specimen, was 9 percent. An electrical moisture meter was used for determining the moisture content. To calibrate the meter for the wood in the subflooring and finish flooring, six samples of each were dried in an oven at 212° F until the weight was constant. The moisture content was the difference between the initial weight and the weight when ovendry, expressed as a percentage of the weight when ovendry. The average value for the southern yellow pine (subflooring) was 0.4 greater than the average of the meter readings; and for the oak (finish flooring) was 0.6 less than the average of the meter readings. Therefore the moisture content of the subflooring was obtained by adding 0.4 to the meter readings, and that of the finish flooring by subtracting 0.6. The results were rounded to the nearest whole number.

3. Nails

The nails were made from steel wire and are described in table 4. Wheeling Steel Corporation.

TABLE 4.—*Description of nails*

Type	Size	Length	Steel wire gage	Diameter of wire, uncoated	Head	Finish
	Penny	*in.*	*No.*	*in.*	*in.*	
Brad, common, light-gage		2	16	0.0625	----	Bright.
Common	4	1½	12½	.0985	----	Cement-coated.
Do	7	2⅛	12½	.0985	----	Do.
Finishing	4	1½	15	.0720	----	Bright.
Plasterboard		1	13	.0915	5/16	Blued.

4. Screws

Self-tapping, case-hardened, cadmium-plated; three sizes: No. 6 (0.138-in. diam), ⅝ in.

long, 18 threads per in., countersunk oval head; No. 8 (0.164-in. diam), two lengths, ¾ in. and 1¼ in., 15 threads per in., binding head; No. 10 (0.190-in. diam), 1¼ in. long, 12 threads per in., binding head. Parker-Kalon Co., Type "A."

5. Bolts and Nuts

Stove bolts, mild steel, ⅜-in. diam, ¾-in. long, 16 threads per in., threaded full length, cadmium-plated. Hexagon nuts, ¼ in. thick, ⅝ in. across flats, cadmium-plated.

6. Mineral Wool

Mineral wool, made from a mixture of lead blast-furnace slag, flint rock, iron oxide, and other siliceous materials, melted at high temperature. A jet of steam blows a stream of the molten mixture into woolly fibers. The specific gravity is about 1.6.

The fibers are felted into batts 4 in. thick and 15 by 48 in. The thermal conductivity is 0.27 (Btu/hr ft^2)/(°F/in.) at 103° F. To provide a vapor barrier a waterproof kraft paper, weight 50 lb/ream (2,880 ft^2), is fastened to one side of the batts by emulsified asphalt adhesive. The paper was manufactured by the Scutan Division of the Union Bag & Paper Corporation. Mineral-wool batts, Eagle-Picher Lead Co., "Eagle Type H3 Ful-Thik."

7. Adhesive

Emulsified asphalt, composed of 74 percent of bituminous material, 17 percent of asbestos fiber, and 9 percent of fine mineral filler. Moisture content less than 0.1 percent. Specific gravity at 77° F, 1.140. Ash content, after calcining at red heat, 22 percent. Philip Carey Co., "Noah's Pitch."

8. Roof Insulating Board

Wood-fiber boards, manufactured by treating wood with high-pressure steam, without the use of chemicals, then felting together the resulting fibers and compressing into boards.

Roof insulating boards, 1 in. thick, 48 by 50 in.; thermal conductivity, 0.33 (Btu/hr ft^2)/(°F/in); and water absorption after 72-hr immersion, 15.8 percent by volume. Masonite Corporation, "Masonite" roof insulation.

9. Roofing

Felt.—Rag base, saturated with asphalt; weight, 15 lb/100 ft^2; roll width, 36 in. Philip Carey Co., "Feltex."

Asphalt.—Blended; softening point, 190° to 200° F; penetration, determined in accordance with ASTM Standard D 5–25, at 77° F (weight on needle, 100 g; time, 5 sec), 25 to 35; penetration at 32° F (200 g, 60 sec), greater than 15; penetration at 150° F (50 g, 5 sec), less than 60; ductility, determined in accordance with ASTM D 113–35, greater than 2; solubility in carbon tetrachloride, determined in accordance with ASTM D 165–27, 99.5 percent; and percentage of ash, none. Philip Carey Co., "Nabosar."

10. Gypsum Wallboard

Sheets, ½ in. thick, consisting of a core of gypsum, sheathed in news-lined chipboard. The core was approximately 98 percent of gypsum and 2 percent of finely divided cellulose fiber by weight.

The weight was 2,270 lb/1,000 ft^2. The average transverse strength, determined in accordance with Federal Specification SS–W–51a, Wallboard; Gypsum, was 48 lb loaded parallel to the fibers of the surfacing and 150 lb loaded across the fibers. The wallboard complied with the requirements of the specification for weight and strength. United States Gypsum Co., "Sheetrock."

11. Paint

Gray baking primer, weight 8½ lb/gal. The formula is given in table 5.

Table 5.—*Formula for the paint*

[Pigment, 16.6 percent; vehicle, 83.4 percent, by weight]

Pigment		Vehicle	
Ingredient	Content, by weight	Ingredient	Content, by weight
	Percent		*Percent*
Zinc sulfide	94.5	Synthetic resin [a]	20.0
Zinc chromate	5.5	Processed china wood oil and linseed oil	24.0
Lampblack	Trace	Mineral spirits	51.0
		VMP naphtha	5.0

[a] Modified polybasic acid, polyhydric alcohol resin.

The paint was formulated for use in baking. The viscosity was 90 to 100 sec (Ford No. 4 cup),

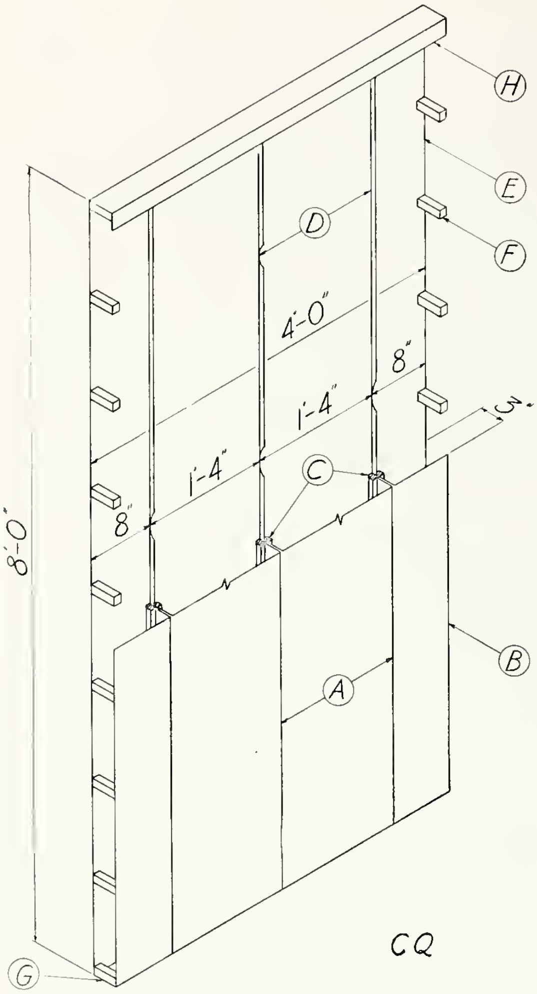


FIGURE 2.—*Four-foot wall specimen CQ*

A, full-width outside panels; *B*, half-width outside panels; *C*, nailing strips; *D*, full-width inside panels; *E*, half-width inside panels; *F*, spacer blocks; *G*, floor plate; *H*, top plate.

and the coverage was 1,000 ft²/gal. The Kay & Ess Co., "No. 9529 Gray Primer."

V. WALL *CQ*

1. Sponsor's Statement

Wall *CQ* consisted of prefabricated sheet-steel channels joined at the flanges, the webs forming the outside face. The inside face was formed of steel sheets. The space between the inside and the outside face was filled with mineral wool. The entire surface of the sheet steel was covered with paint.

The price of this construction in Washington, D. C., as of July 1937, was \$0.54/ft².

(*a*) *Four-Foot Wall Specimens*

Each 4-ft wall specimen, as shown in figure 2, was 8 ft 0 in. high, 4 ft 0 in. wide, and 3 in. thick. Each specimen consisted of two full-width channel-shaped outside panels, *A;* two half-width outside panels, *B;* nailing strips, *C;* two full-width inside panels, *D;* two half-width inside panels, *E;* spacer blocks, *F;* a floor plate, *G;* and a top plate, *H.*

Outside panels.—The full-width outside panels, *A*, were sheet steel, No. 18 U. S. Std. Gage (0.0490 in. thick), 7 ft 11⅞ in. long, 1 ft 4 in. wide, and 2⅞ in. deep. The half-width outside panels, *B*, were the same as one-half of a full-width panel, *A*, divided along the longitudinal

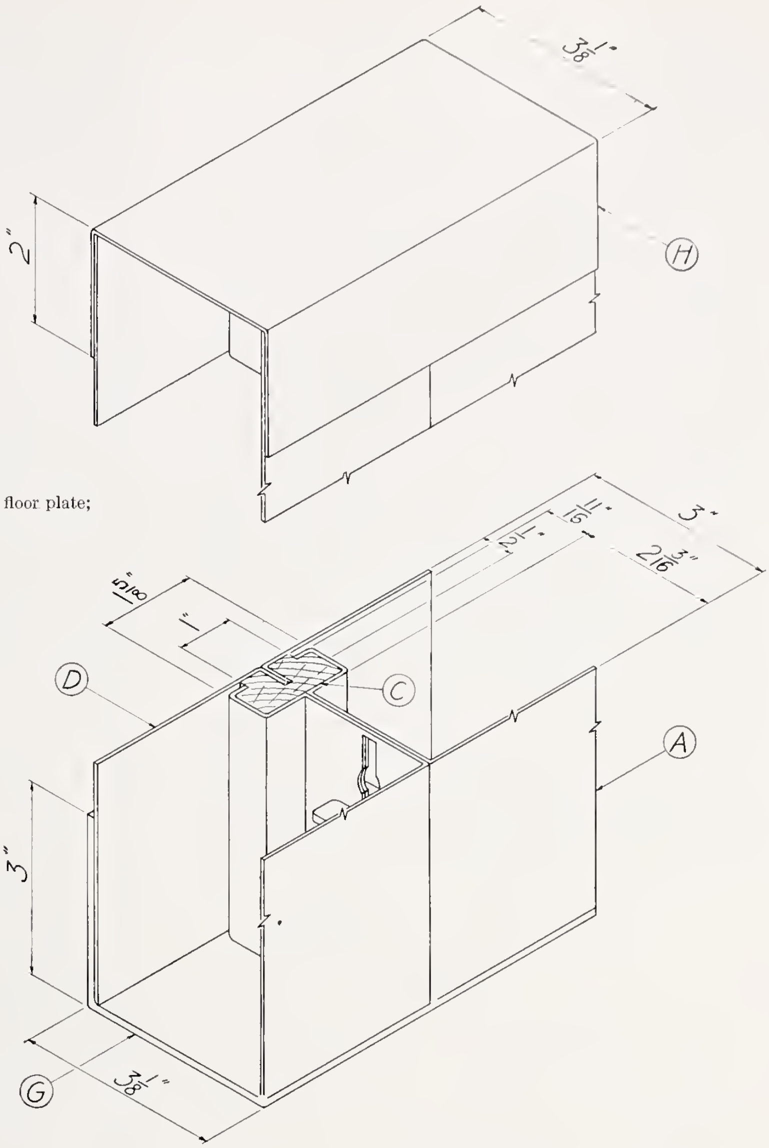


Figure 3.—*Details of wall CQ.*

A, outside panel; *C*, nailing strip; *D*, inside panel; *G*, floor plate; *H*, top plate.

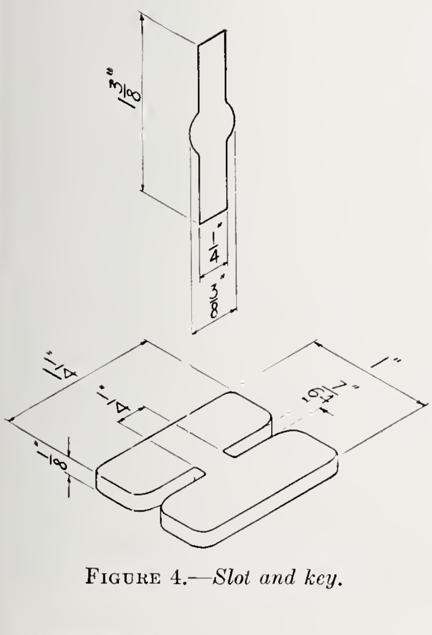


Figure 4.—*Slot and key.*

center line. They are not used in a house. The flanges on adjacent panels enclosed a wood nailing strip, as shown in figure 3.

There were six longitudinal slots in each flange, $1\frac{17}{32}$ in. from the web, spaced 1 ft 6 in. on centers. The centers of the end slots were $2\frac{15}{16}$ in. from the ends of the panel. The panels were locked together by H-shaped keys, shown in figure 4, which were inserted through the slots, turned 90°, and driven against one end of the slot. The keys were sheet steel, No. 11 U. S. Std. Gage (0.1225 in. thick), plated with cadmium. The position of a key in a slot is shown in figure 5.

218548°—40——2

Mineral-wool batts were fastened by emulsified asphalt adhesive to the inner surface of the full-width outside panels.

Nailing strips.—The nailing strips, *C*, were yellow poplar, 7 ft 11⅞ in. long, $2^{23}/_{32}$ by $1^{7}/_{16}$ in., S4S. The strips were enclosed by the flanges of the outside panels.

Inside panels.—The full-width inside panels, *D*, were sheet steel, No. 18 U. S. Std. Gage (0.0490 in. thick), 7 ft 11⅞ in. long, 1 ft 4 in. wide. The longitudinal edges were flanged ½ in. The half-width inside panels, *E*, were the same as one-half of a full-width panel, *D*, divided along the longitudinal center line. They are not used in a house.

The flanges of the panels fitted into the grooves in the nailing strips, and each panel was fastened to a nailing strip at each edge by ⅝-in. No. 6 self-tapping screws, spaced 1 ft 6 in. The screws passed through the face of each panel into the thicker portion of each nailing strip.

Spacer blocks.—The spacer blocks, *F*, were yellow poplar, $2^{15}/_{16}$ in. long, 1 by 1 in., S2S, nine blocks along each edge of the specimen, spaced 1 ft on centers. Each spacer was fastened to each face by one ¾-in. No. 8 self-tapping screw through the half-width panels into the end of the spacer. These spacer blocks are not used in a house.

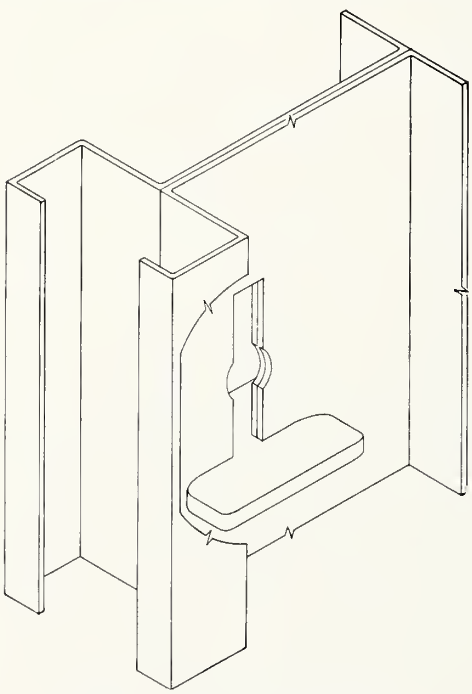


Figure 5.—*Position of key in slot.*

Method of locking together adjacent panels in wall, floor, and roof constructions.

Floor plate.—The floor plate, *G*, was a sheet-steel angle, No. 12 U. S. Std. Gage (0.1072 in. thick), 3 ft $11^{15}/_{16}$ in. long, 3 by 3⅛ in. There were three 1-in. holes for anchor bolts in the horizontal (3⅛-in.) leg, spaced 1 ft 6 in. on centers and 1⅛ in. from the face of the vertical (3-in.) leg. The end holes were spaced $5^{31}/_{32}$ in. from the ends of the angle. The floor plate was fastened to the panels by 1¼-in. No. 10 self-tapping screws, passing through the vertical leg of the angle, the face of the inside panels, the wood nailing strips, and the flanges (of the outside panels) back of the strips; one screw through each inside panel. Also, the vertical leg of the floor plate was fastened to the bottom spacer blocks by ¾-in. No. 8 self-tapping screws, one into each block.

Top plate.—The top plate, *H*, was a sheet-steel channel, No. 20 U. S. Std. Gage (0.0368 in. thick), 3 ft $11^{15}/_{16}$ in. long, 2 by 3⅛ in. It fitted snugly over the top of the wall panels and was fastened to each outside and inside panel by one ¾-in. No. 8 self-tapping screw. On the outside face the screws passed through the flange of the top plate and the face of the outside panels; on the inside face, through the flange of the plate, the face of the inside panels, and into the thicker portion of the nailing strips. The plate was also fastened to the top spacer blocks by No. 8 self-tapping screws, two to each block, one through each flange of the channel. This type of top plate is not used in a house.

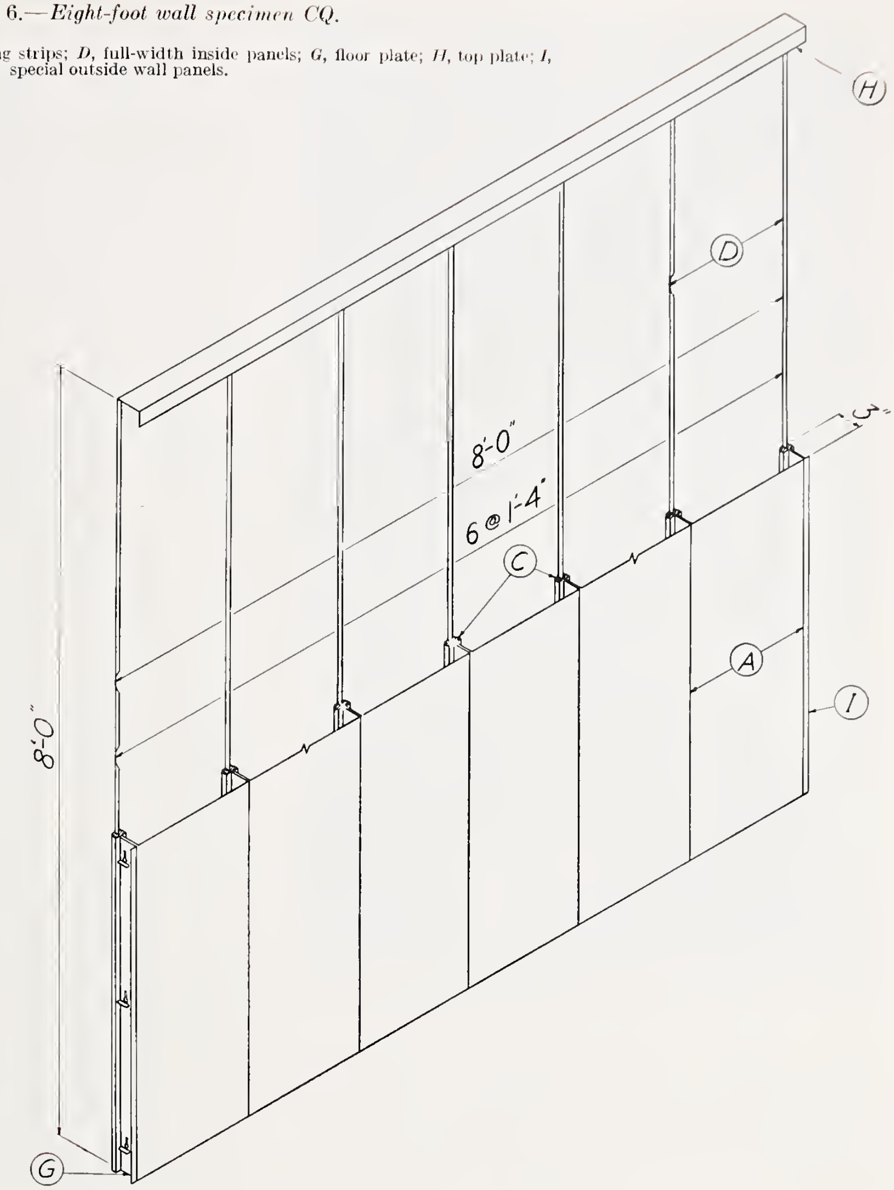
Paint.—The entire surface of each piece of steel was covered in the shop with one coat of primer, applied by spraying, and then baked 1 hour at 200° F.

(b) *Eight-Foot Wall Specimens*

The 8-ft wall specimens, shown in figure 6, were 8 ft 0 in. high, 8 ft 0 in. face width, and 3 in. thick. They were similar to the 4-ft specimens except that there were six full-width panels on both faces and no half-width panels or spacers. There were also two special outside wall panels, *I*, $1^{3}/_{16}$ in. face width, fastened to the outer flanges of the edge full-width panels in order to make the flange assemblies at the

FIGURE 6.—*Eight-foot wall specimen CQ.*

A, full-width outside panels; *C*, nailing strips; *D*, full-width inside panels; *G*, floor plate; *H*, top plate; *I*, special outside wall panels.



edges of the specimens like the intermediate flange assemblies. The over-all width was 8 ft 1⅝ in. As in an actual house, there was a No. 8 self-tapping screw through the contacting flanges of adjacent wall panels, approximately ½ in. above the lower ends. This fastening was omitted in the 4-ft specimens.

Both floor plate and top plate were each 7 ft 11$^{15}/_{16}$ in. long. All the steel parts were painted as in the 4-ft wall specimens.

(*c*) *Comments*

Standard wall panels are 1 ft 4 in. wide. Other widths are furnished if required, the minimum being 4½ in. The maximum height of a single panel is 14 ft 0 in., but panels can be spliced in the shop to obtain greater heights. No special equipment or tools are required to assemble the panels for a house.

Any conventional type of masonry foundation may be used. A continuous angle floor plate or sill is set on an asphalt-impregnated felt strip 3 in. wide and ⅛ in. thick. The strip is laid in a coating of asphalt mastic, with which it is completely covered before the sill is laid. The sill is fastened by ⅜-in. anchor bolts spaced about 2 ft 0 in.

Corners are 90° panels, 8 by 8 in. Openings

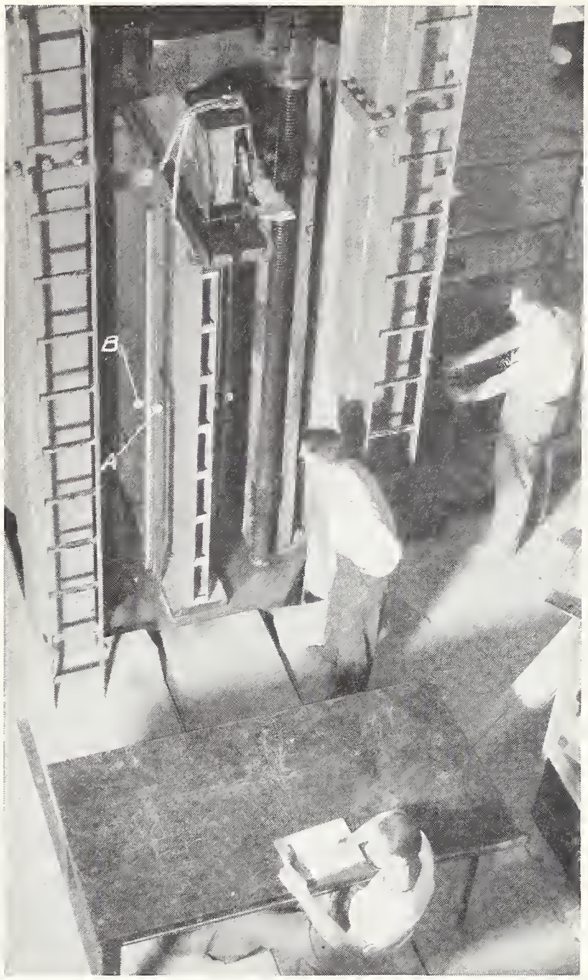


FIGURE 7.—*Wall specimen CQ–C1 under compressive load.*

A, compressometer; *B*, deflectometer.

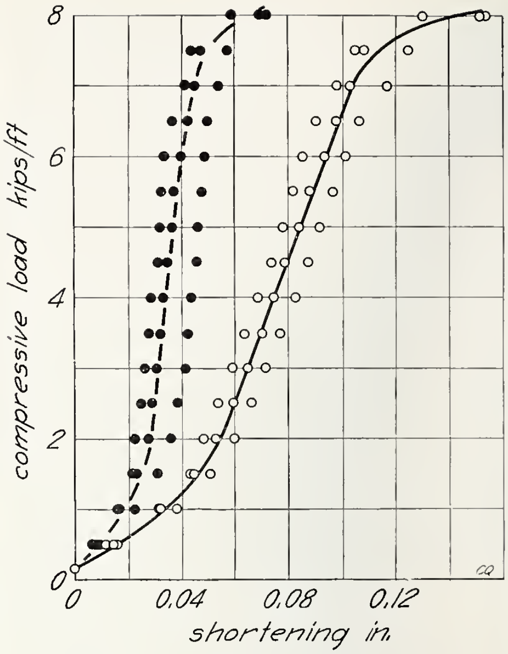


FIGURE 8.—*Compressive load on wall CQ.*

Load-shortening (open circles) and load-set (solid circles) results for specimens *CQ–C1, C2,* and *C3*. The load was applied 1.0 in. (one-third the thickness of the wall) from the inside face. The loads are in kips per foot of actual width of specimen. The shortenings and sets are for a gage length of 8 ft 0 in., the height of the specimens.

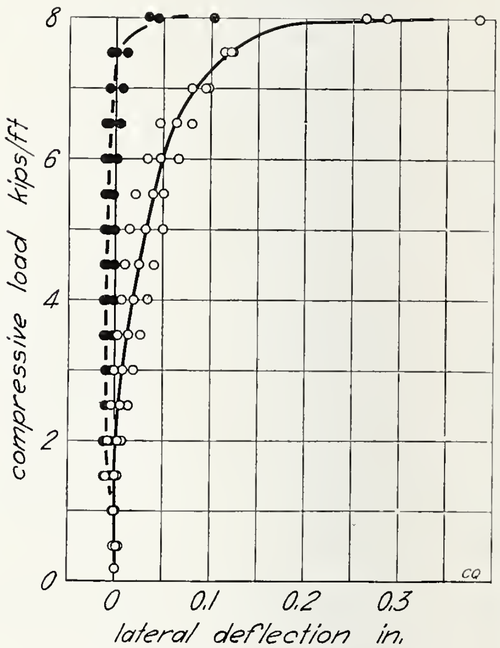


FIGURE 9.—*Compressive load on wall CQ.*

Load-lateral deflection (open circles) and load-lateral set (solid circles) results for specimens *CQ–C1, C2,* and *C3*. The load was applied 1.0 in. (one-third the thickness of the wall) from the inside face. The loads are in kips per foot of actual width of specimen. The deflections and sets are for a gage length of 7 ft 6 in., the gage length of the deflectometers.

for doors and windows are cased with metal frames formed from sheet steel, No. 16 U. S. Std. Gage. The frames rest on angle sills, and the panels above the openings are supported by angle lintels. Sills and lintels are sheet steel, No. 12 U. S. Std. Gage.

Wall panels extend above the roof and are capped by a continuous sheet-steel coping, fastened by screws.

Baked enamel finish can be supplied in any color. Additional painting in the field is not necessary.

2. Compressive Load

Wall specimen *CQ–C1* under compressive load is shown in figure 7. The results for wall specimens *CQ–C1, C2,* and *C3* are given in table 6 and in figures 8 and 9.

Table 6.—*Structural properties of wall CQ*

[Weight, 6.84 lb/ft²]

Compressive load [a]		Transverse load [b]		Concentrated load		Impact load [b]		Racking load	
Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum height of drop	Specimen	Maximum load
	[c] *Kips/ft*		*lb/ft²*		*lb*		*ft*		[c] *Kips/ft*
C1	8.02	*T1*	200	*P1*	[d] 1,000	*I1*	[d] 10.0	*R1*	0.85
C2	8.45	*T2*	188	*P2*	[d] 1,000	*I2*	[d] 10.0	*R2*	.74
C3	8.35	*T3*	198	*P3*	[d] 1,000	*I3*	[d] 10.0	*R3*	.70
Average	8.27	Average	195	Average	[d] 1,000	Average	[d] 10.0	Average	0.76
		T4	162	*P4*	[d] 1,000	*I4*	[d] 10.0		
		T5	163	*P5*	[d] 1,000	*I5*	[d] 10.0		
		T6	155	*P6*	[d] 1,000	*I6*	[d] 10.0		
		Average	160	Average	[d] 1,000	Average	[d] 10.0		

[a] Load applied 1 in. (one-third the thickness of the wall) from the inside face.
[b] Span 7 ft 6 in.
[c] A kip is 1,000 lb.
[d] Specimen did not fail. Test discontinued.

The speed of the movable head of the testing machine was 0.044 in./min. The lateral deflections shown in figure 9 were plotted to the right of the vertical axis for deflections of the specimen toward the outside face and to the left of the axis for deflections toward the inside face.

Under a load of 2.5 kips/ft both inside half-width panels of specimens *CQ–C1* and *C2* separated ⅛ in. from the nailing strips near midheight. In specimen *C3* the same separation occurred under a load of 3.5 kips/ft. The edges of the inside face of specimen *C1* buckled between spacers under 3.0 kips/ft. Under a load of 8.0 kips/ft the two full-width inside panels of *C1* buckled, 1 ft from the bottom, and under the maximum load the flanges of the outside panel at one edge of the specimen also buckled, near midheight. In specimen *C2* under a load of 7.0 kips/ft the two full-width inside panels buckled, one near midheight and the other 1 ft from the bottom. Under the maximum load the outside panels buckled near the bottom. In specimen *C3* under a load of 8.0 kips/ft one full-width inside panel buckled 1 ft from the bottom. Under the maximum load the buckled panel folded, and the separation of the other panels from the nailing strips was about 1½ in.

3. Transverse Load

Wall specimen *CQ–T5* under transverse load is shown in figure 10. The results are given in table 6 and in figure 11 for wall specimens *CQ–T1*, *T2*, and *T3*, loaded on the inside face, and in figure 12 for specimens *CQ–T4*, *T5*, and *T6*, loaded on the outside face.

The inside (loaded) face of specimen *CQ–T1* separated from the nailing strips under a load of 180 lb/ft². In *T2* the separation took place under a load of 140 lb/ft², and in *T3* under 120 lb/ft². Under the maximum loads the flanges of the outside panels buckled between the loading rollers, at the nailing strips. The faces of the specimens were not damaged.

Under a load of 160 lb/ft² on specimens *CQ–T4* and *T5* the loaded (outside) faces buckled transversely between loading rollers. Under the maximum load the loaded faces of each of these specimens continued to crumple, and in addition the flanges of the outside panels buckled. In specimen *T6* the buckling of the loaded face and of the flanges occurred under the maximum load.

4. Concentrated Load

Results of concentrated-load tests are given in table 6, and in figure 13 for wall specimens *CQ–P1*, *P2*, and *P3*, loaded on the inside face, and in figure 14 for wall specimens *CQ–P4*, *P5*, and *P6*, loaded on the outside face.

The concentrated loads were applied to the inside face of specimens *CQ–P1*, *P2*, and *P3* on the center of a full-width inside panel, 15 in. from one end. Under a load of 400 lb on specimen *P1*, 500 lb on specimen *P2*, and 600 lb on specimen *P3* the nailing strip along one edge of the loaded panel split in the groove,

FIGURE 10.—*Wall specimen CQ–T5 under transverse load.*

beginning at one end of the strip and extending 1½ ft. After a load of 1,000 lb had been applied to specimens *P1*, *P2*, and *P3* the sets were 0.98, 0.86, and 1.02 in., respectively.

The concentrated loads were applied to the outside face of specimens *CQ–P4*, *P5*, and *P6* on the middle of a full-width outside panel, 15 in. from one end. Under a load of 400 lb on each specimen the panel joints on each side of the concentrated load opened about ½ in., and continued to open further as the load was increased. Under a load of 700 lb the end of the loaded panel of specimen *P4* made contact with the opposite face of the wall, which rested on the steel plate. After a load of 1,000 lb had been applied to specimens *P4*, *P5*, and *P6* the sets were 1.18, 1.25, and 1.21 in., respectively.

5. Impact Load

Impact-test results are shown in table 6, and in figure 15 for wall specimens *CQ–I1*, *I2*, and *I3*, loaded on the inside face, and in figure 16 for specimens *CQ–I4*, *I5*, and *I6*, loaded on the outside face.

The impact loads were applied to the center of the inside face of specimens *CQ–I1*, *I2*, and *I3*, the sandbag striking the sheet steel directly over the joint between the two full-width inside panels. The effects are given in table 7.

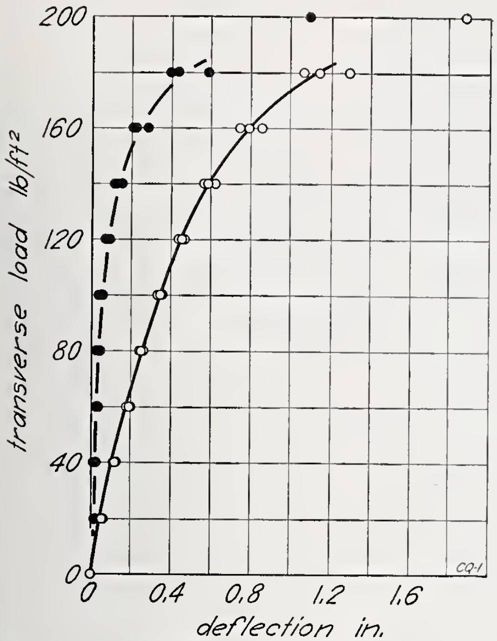


FIGURE 11.—*Transverse load on wall CQ, load applied to inside face.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *CQ-T1, T2,* and *T3* on the span 7 ft 6 in.

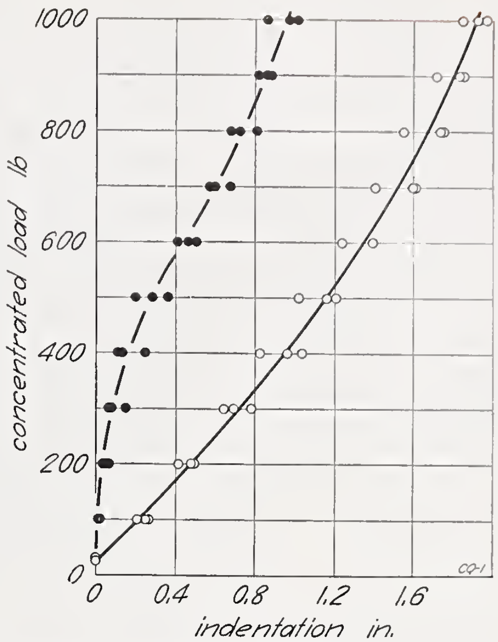


FIGURE 13.—*Concentrated load on wall CQ, load applied to inside face.*

Load-indentation (open circles) and load-set (solid circles) results for specimens *CQ-P1, P2,* and *P3.*

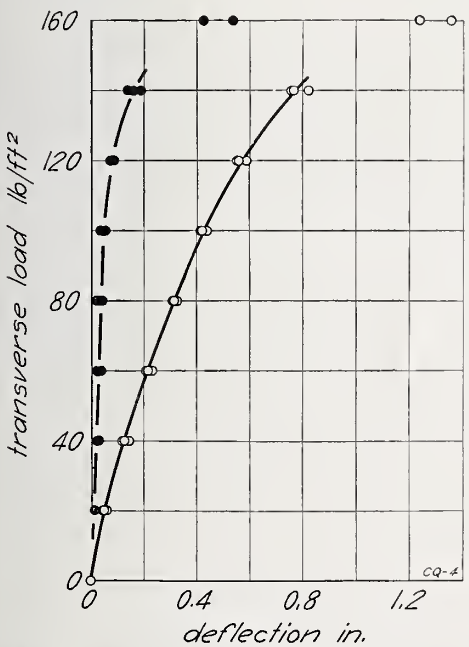


FIGURE 12.—*Transverse load on wall CQ, load applied to outside face.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *CQ-T4, T5,* and *T6* on the span 7 ft 6 in.

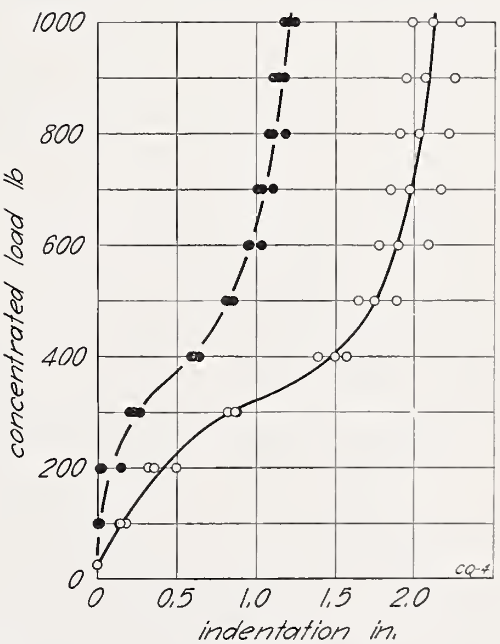


FIGURE 14.—*Concentrated load on wall CQ, load applied to outside face.*

Load-indentation (open circles) and load-set (solid circles) results for specimens *CQ-P4, P5,* and *P6.*

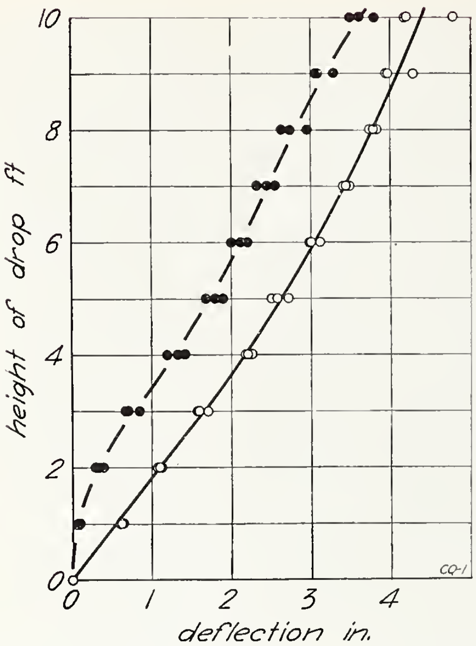


FIGURE 15.—*Impact load on wall CQ, load applied to inside face.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *CQ–I1, I2,* and *I3* on the span 7 ft 6 in.

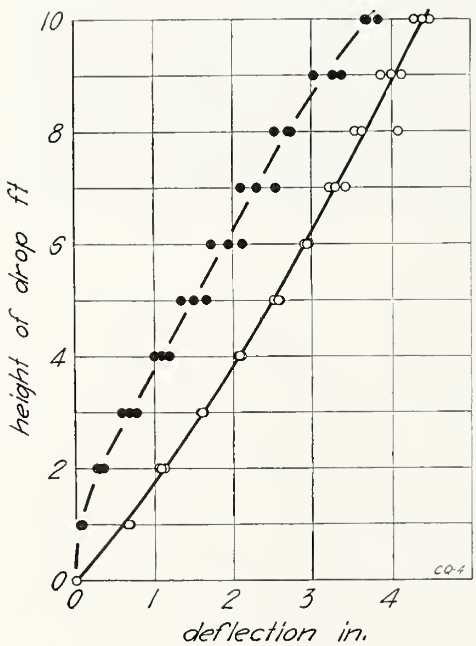


FIGURE 16.—*Impact load on wall CQ, load applied to outside face.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *CQ–I4, I5,* and *I6* on the span 7 ft 6 in.

TABLE 7.—*Effects of impact load on wall CQ, loaded on the inside face*

Description of effects	Specimen *I1*		Specimen *I2*		Specimen *I3*	
	Height of drop	Deflection	Height of drop	Deflection	Height of drop	Deflection
Face loaded:						
Full-width panels separated ¼ in. from each other at midheight	*ft* 4.0	*in.* 2.18	*ft* 4.0	*in.* 2.20	*ft* 4.5	*in.* 2.46
One full-width panel separated ½ in. from outer nailing strip at midheight	7.0	3.41	6.5	3.22	7.0	3.49
Center nailing strip split longitudinally	4.0	2.18	3.5	1.97	4.0	2.25
Face not loaded: Full-width panels separated ¼ in. from each other at midheight, except at the keys	4.0	2.18	3.5	1.97	4.0	2.25

After the 10-ft drop the sets in specimens *CQ–I1, I2,* and *I3* were 3.62, 3.50, and 3.81 in., respectively. The outer (half-width) panels on the inside face were buckled slightly.

The impact loads were applied to the center of the outside face of specimens *CQ–I4, I5,* and *I6,* the sandbag striking the sheet steel directly over the joint between the two full-width outside panels. The effects are given in table 8.

TABLE 8.—*Effects of impact load on wall CQ, loaded on the outside face*

Description of effects	Specimen *I4*		Specimen *I5*		Specimen *I6*	
	Height of drop	Deflection	Height of drop	Deflection	Height of drop	Deflection
Face loaded:						
Full-width panels dished where struck by sandbag	*ft* 3.0	*in.* 1.61	*ft* 3.0	*in.* 1.58	*ft* 3.5	*in.* 1.86
Full-width panels separated ¼ in. from each other at midheight, except at the keys	4.0	2.10	4.5	2.31	4.5	2.30
One full-width panel buckled ½ in. inward at floor plate	6.0	2.93	5.0	2.56	6.5	3.05
One full-width panel buckled ½ in. inward at top plate	6.0	2.93	7.0	3.41	6.5	3.05
Center nailing strip split longitudinally	5.0	2.56	5.5	2.62	5.5	2.69
Face not loaded: Full-width panels separated ¼ in. from each other at midheight	5.0	2.56	5.5	2.62	5.5	2.69

After the 10-ft drop the sets in specimens *CQ–I4, I5,* and *I6* were 3.84, 3.68, and 3.70 in., respectively. The half-width panels on the outside face were buckled slightly.

6. RACKING LOAD

Wall specimen *CQ–R3* under racking load is shown in figure 17. The results for wall specimens *CQ–R1, R2,* and *R3* are given in table 6 and in figure 18.

The top plate and one or more outside and inside panels buckled under loads of 0.6, 0.5, and 0.3 kip/ft on specimens *CQ–R1, R2,* and *R3,* respectively. Under the maximum load

FIGURE 17.—*Wall specimen CQ–R3 under racking load.*

A, deformeter.

on specimen *R1* the top plate buckled further, between screws; all outside and inside panels buckled; and two screws through the floor plate into the middle panels ruptured in tension, due to the buckling. In specimen *R2* under the maximum load the top plate and all panels except three on the outside face buckled; the vertical displacement between adjacent panels was about 0.15 in., and the heads of all the screws connecting the floor plate to the panels sheared off. In specimen *R3* under the maximum load the top plate crumpled further, all panels except one on the inside face and two on the outside face buckled, and the vertical displacement between adjacent panels was about 0.10 in.

VI. FLOOR *CR*

1. SPONSOR'S STATEMENT

Floor *CR* consisted of prefabricated sheet-steel channels joined at the flanges, the webs forming the lower face. The upper face was composed of subflooring and finish flooring. The entire surface of the steel was covered with paint.

The price of this construction in Washington D. C., as of July 1937, was \$0.56/ft^2.

(*a*) *Description*

The floor specimens, shown in figure 19, were 12 ft. 6 in. long, 4 ft. 2 in. wide, and 7¾ in. thick. Each consisted of four full-width channel-shaped floor panels, *A;* two half-width panels, *B;* nailing strips, *C;* spacer blocks, *D;* edge strips, *E;* headers, *F;* subflooring, *G;* and finish flooring, *H*.

Floor panels.—The full-width floor panels, *A*, were sheet steel, No. 18 U. S. Std. Gage (0.0490 in. thick), 12 ft. 5$^{15}/_{16}$ in. long, 10 in. wide, and 6 in. deep. The half-width floor panels, *B*, were the same as one-half of a full-width panel, *A*, divided along the longitudinal center line.

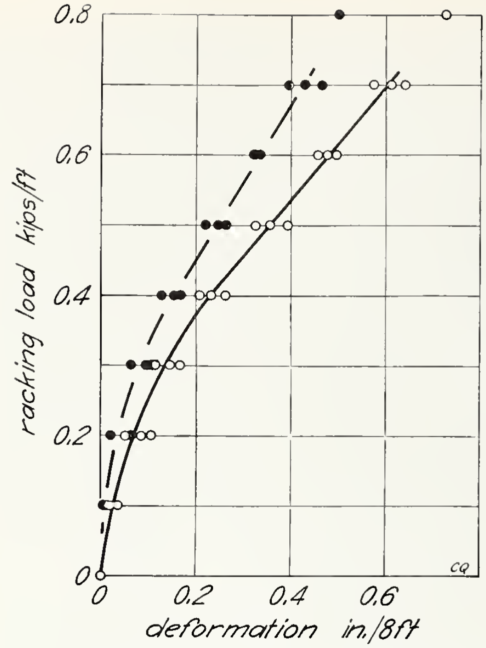


Figure 18.—*Racking load on wall CQ.*

Load-deformation (open circles) and load-set (solid circles) results for specimens *CQ–R1*, *R2*, and *R3*. The loads are in kips per foot of actual width of specimen. The deformations and sets are for a gage length of 7 ft 11¼ in., the gage length of the deformeter.

They are not used in a house. The flanges of adjacent panels enclosed a wood nailing strip, as shown in figure 20.

There were nine horizontal slots in each flange, spaced 1 ft 6 in. on centers and 1$^{17}/_{32}$ in. from the web of the panel. The centers of the end slots were 2$^{31}/_{32}$ in. from the ends of the flange. Panels were locked together by H-shaped keys, which were inserted through the slots, turned 90°, and driven against one end of the slot. The keys were sheet steel, No. 11 U. S. Std. Gage (0.1225 in. thick), plated with cadmium. The details of the slot and key connections were the same as in the wall specimens, shown in figures 4 and 5.

Nailing strips.—The nailing strips, *C*, were yellow poplar, 12 ft 5$^{15}/_{16}$ in. long, $^{23}/_{32}$ by 1$^{7}/_{16}$ in., S4S. The strips were enclosed by the flanges of the floor panels.

Spacer blocks.—The spacer blocks, *D*, were yellow poplar, 5$^{3}/_{16}$ in. long, 1⅝ by 2 in., S2S, 13 along each edge of the specimen, spaced 1 ft. on centers. Each block was fastened to the

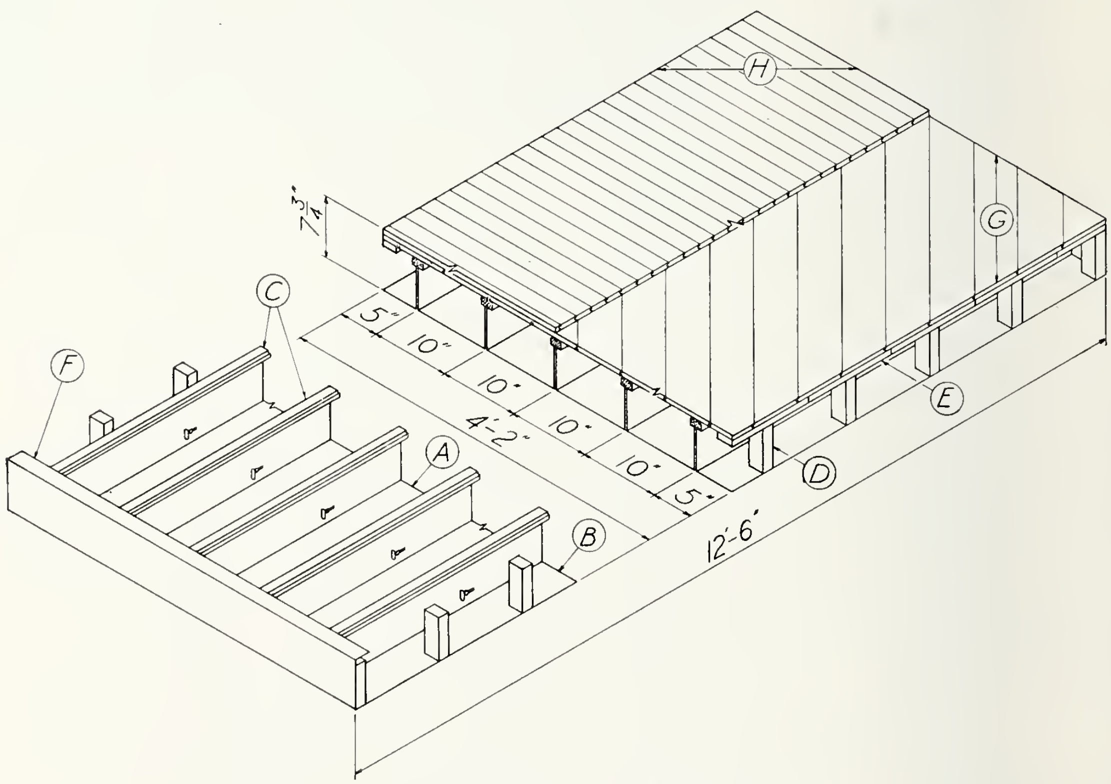


Figure 19.—*Floor specimen CR.*

A, full-width floor panels; *B*, half-width floor panels; *C*, nailing strips; *D*, spacer blocks; *E*, edge strip; *F*, headers; *G*, subflooring; *H*, finish flooring.

web of the half-width panels by one ¾ in. No. 8 self-tapping screw, passing through the web into the block. Spacer blocks are not used in a house.

Edge strips.—The edge strips, *E*, were yellow poplar, 12 ft 5¹⁵⁄₁₆ in. long, ⅞ by 2 in., S2S, and were placed over the spacer blocks along each edge of the specimen to provide continuous support while the flooring was being laid and when the specimens were handled. Each strip was fastened to each spacer block by two 7d cement-coated common nails passing through the edge strip into the spacer.

Before the specimens were tested, the strips were sawed through between adjacent blocks and therefore had no appreciable effect on the structural properties of the specimens. Edge strips are not used in a house.

Headers.—The headers, *F*, were sheet-steel channels, No. 20 U. S. Std. Gage (0.0368 in. thick), 4 ft 1¹⁵⁄₁₆ in. long, 6⁵⁄₃₂ in. wide, and 2 in. deep. Each was fastened to the floor panels by No. 8 self-tapping screws, one to each nailing strip through the upper flange and four through the lower flange. Each screw through the upper flange was 1¼ in. long and passed through the flange of the header, the nailing strip, and the flange (of the floor panel) back of the nailing strip. Two additional No. 8 screws passed through the upper flange of the header, one into each end spacer block. Each screw through the lower flange was ¾ in. long and passed through the flange of the header and the web of a floor panel, two of the screws entering the end spacer blocks and the other two being equally spaced between them.

Headers of this type are not used in a house.

Subflooring.—The subflooring, *G*, was southern yellow pine, ²⁵⁄₃₂ in. thick by 5³⁄₁₆ in. face width, and was laid at an angle of about 45° with the panels. Each piece was fastened to each nailing strip and each edge strip by two 4d cement-coated common nails.

Finish flooring.—The finish flooring, *H*, was white oak, ²⁵⁄₃₂ in. thick by 2¼-in. face width. Each piece was blind-fastened through the sub-

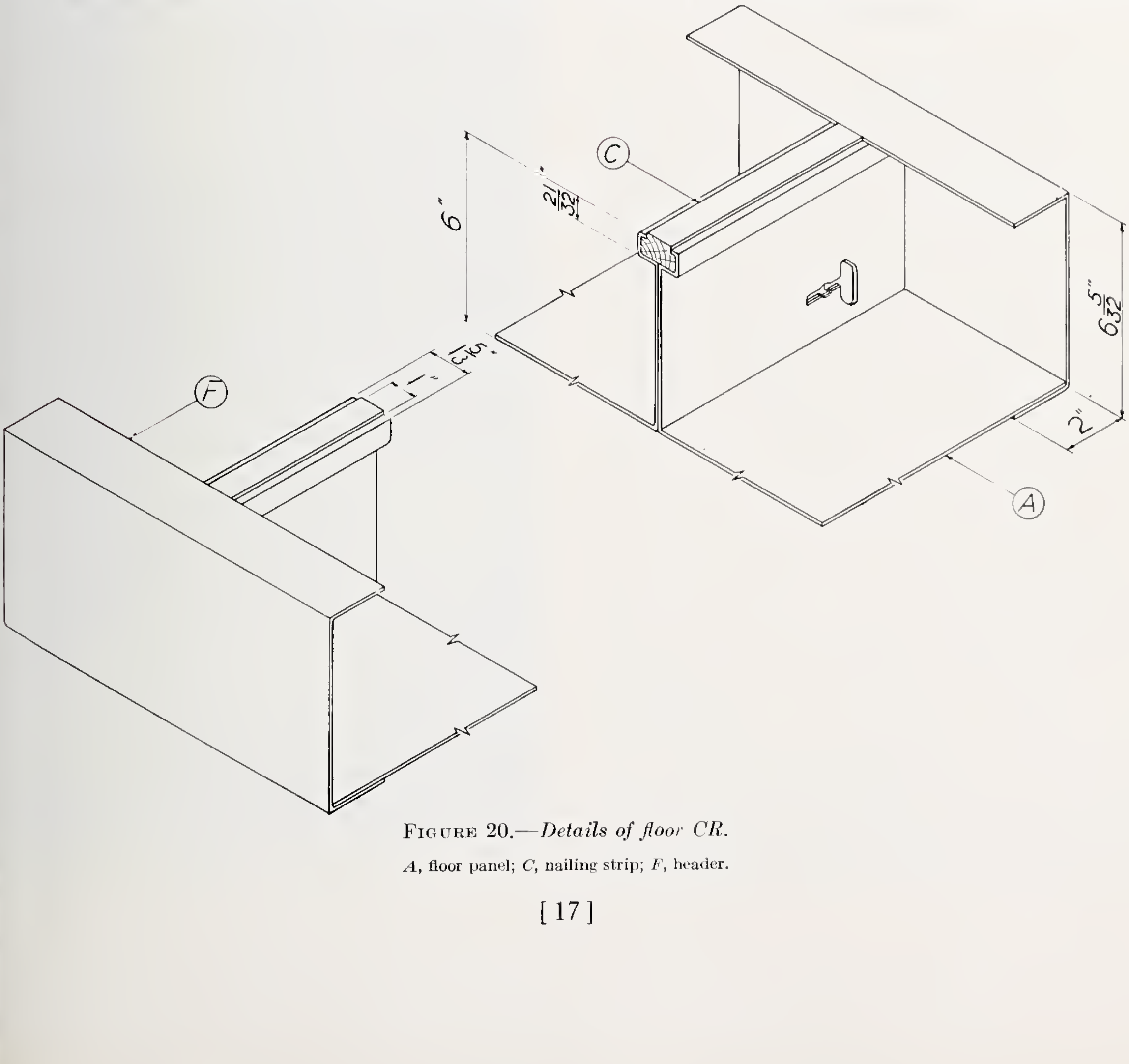


FIGURE 20.—*Details of floor CR.*

A, floor panel; *C*, nailing strip; *F*, header.

flooring to each nailing strip and edge strip, either by one 2-in. light-gage wire brad or by one 4d finishing nail.

Paint.—The entire surface of each piece of steel was covered in the shop with one coat of primer, applied by spraying, and then baked 1 hour at 200° F.

(*b*) *Comments*

Standard floor panels of this construction are 10 in. wide and 6 in. deep, in lengths up to 14 ft. For greater lengths the panels are spliced at midspan. Special sections, varying in both width and depth, are furnished for unusual load requirements. No special equipment or tools are required for erection.

The panels are supported by the foundation wall or by a center girder. The ends are in contact with a continuous angle header, which is coated with asphalt mastic and rests on a strip of asphalt-impregnated felt. Any conventional type of flooring may be applied.

2. Transverse Load

The results for floor specimens *CR–T1, T2,* and *T3* under transverse load are shown in table 9 and in figure 21.

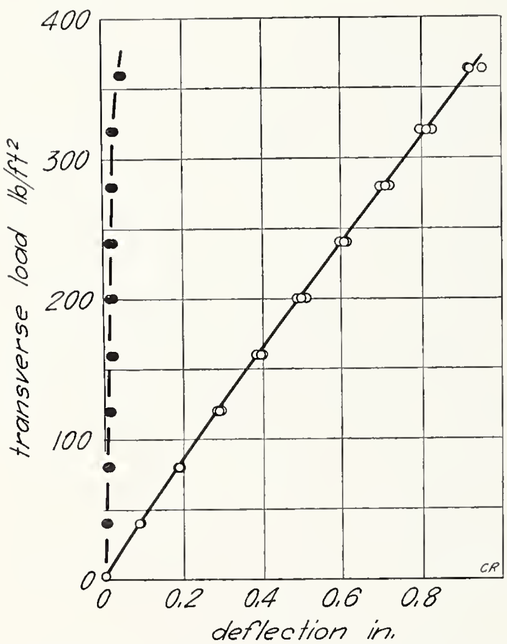


Figure 21.—*Transverse load on floor CR.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *CR–T1, T2,* and *T3* on the span 12 ft 0 in.

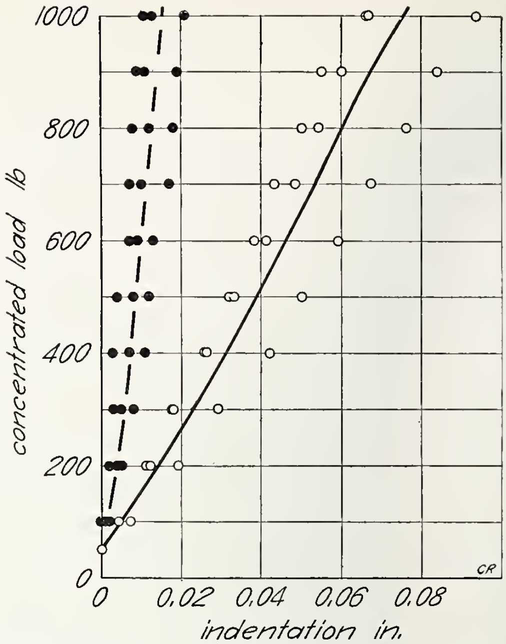


Figure 22.—*Concentrated load on floor CR.*

Load-indentation (open circles) and load-set (solid circles) results for specimens *CR–P1, P2,* and *P3.*

Table 9.—*Structural properties of floor CR*

[Weight, 9.91 lb/ft²]

Transverse load [a]		Concentrated load		Impact load [a]	
Specimen	Maximum load	Specimen	Maximum load	Specimen	Maximum height of drop
	lb/ft²		*lb*		*ft*
T1	390	*P1*	[b] 1,000	*I1*	[b] 10.0
T2	376	*P2*	[b] 1,000	*I2*	[b] 10.0
T3	382	*P3*	[b] 1,000	*I3*	[b] 10.0
Average	383	Average	[b] 1,000	Average	[b] 10.0

[a] Span 12 ft 0 in.
[b] Specimen did not fail.

The speed of the movable head of the testing machine was adjusted to 0.22 in./min.

Under the maximum loads the upper portions of the flanges of all the floor panels in each of the specimens buckled between the loading rollers, but the subflooring and finish flooring were undamaged.

3. Concentrated Load

The results for floor specimens *CR–P1, P2,* and *P3* under concentrated load are shown in table 9 and in figure 22.

The concentrated loads were applied to the upper face of specimens *CR–P1, P2,* and *P3*

over an end-matched joint between two finish-flooring strips.

The sets after a load of 1,000 lb had been applied were 0.021, 0.013, and 0.011 in., respectively, for these specimens, and no other effect was observed.

4. Impact Load

Floor specimen *CR–I1* during the impact test is shown in figure 23. The results for floor specimens *CR–I1*, *I2*, and *I3* are given in table 9 and in figure 24.

The impact loads were applied to the center of the upper face on the finish flooring directly over the joint between the two full-width floor panels. After the 10-ft drop the sets in specimens *CR–I1*, *I2*, and *I3* were 0.022, 0.020, and 0.052 in., respectively, and no other effect was observed.

Figure 23.—*Floor specimen CR-I1 during the impact test.*

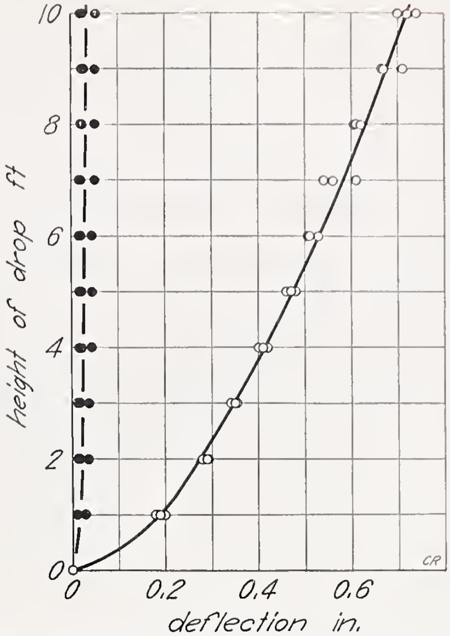


Figure 24.—*Impact load on floor CR.*

Height of drop-deflection (open circles) and height of drop-set (solid circles) results for specimens *CR–I1*, *I2*, and *I3* on the span 12 ft 0 in.

VII. ROOF *CS*

1. Sponsor's Statement

Roof *CS* consisted of prefabricated sheet-steel channels joined at the flanges, the webs forming the roof deck. The upper face was insulating board and asphalt roofing, and the lower was gypsum wallboard. The entire surface of the steel was covered with paint. The same size and type of channel-shaped panel was used in roof *CS* as in floor *CR*, but in the roof construction the lower face of the specimen was fastened to the flanges of the panels, not the upper face, as in the floor specimens.

The price of this construction in Washington, D. C., as of July 1937, was \$0.63/ft^2.

Each roof specimen, as shown in figure 25, was 14 ft 6 in. long, 4 ft 2 in. wide, and 8 in. thick. Each consisted of four full-width roof panels, *A;* two half-width panels, *B;* nailing strips, *C;* spacer blocks, *D;* edge strips, *E;* headers, *F;* insulating board, *G;* roofing, *H;* and gypsum wallboard, *I.*

Roof panels.—The full-width roof panels, *A*, were sheet-steel channels, No. 18 U. S. Std. Gage (0.0490 in. thick), 14 ft 5$^{15}/_{16}$ in. long, 10 in. wide, and 6 in. deep. The half-width roof panels, *B*, were the same as one-half of a

full-width panel, A, divided along the longitudinal center line. They are not used in a house. The flanges of adjacent panels enclosed wood nailing strips, like the floor panels shown in figure 20.

The roof panels were the same as floor panels except in length. Since the maximum length of panel available in one piece is 14 ft 0 in., the panels were fabricated of two pieces, each 7 ft $2^{31}/_{32}$ in. long, joined at midlength by a sheet-steel splice channel, No. 16 U. S. Std. Gage (0.0613 in. thick), 36 in. long, shown in figure 26. The splice channel fitted inside the roof panels and was centered on the joint. Each splice was fastened by 66 spot welds, in 6 transverse rows of 11 welds each (3 welds in each flange and 5 in the web). The rows were 1, 4, and 12 in. from the joint on each side.

There were eight horizontal slots in each flange, four on each side of the splice, spaced 1 ft 6 in. on centers and $1^{17}/_{32}$ in. from the web of the panel. The end slots were respectively, 6 and 9 in., from the ends of the panels. The panels were locked together by H-shaped keys which were inserted through the slots, turned 90°, and driven against one end of the slot. The keys were sheet steel, No. 11 U. S. Std. Gage (0.1225 in. thick), plated with cadmium. The slot-and-key connections were like those in the wall specimens, shown in figures 4 and 5. The flanges of adjacent panels were also joined at the splices by two $^{3}/_{8}$-in. stove bolts, spaced 1 ft 3 in. Each bolt was 1 ft 6 in. from the nearest slot.

Nailing strips.—The nailing strips, C, were yellow poplar, 14 ft $5^{15}/_{16}$ in. long, $^{23}/_{32}$ by $1^{7}/_{16}$ in., S4S, and were enclosed by the flanges of the roof panels.

Spacer blocks.—The spacer blocks, D, were yellow poplar, $5^{3}/_{16}$ in. long, $1^{3}/_{8}$ by 2 in., S2S, 15 along each edge of a specimen, spaced 1 ft on centers. Each block was fastened to the web of the half-width panels by one $^{3}/_{4}$-in. No. 8 self-tapping screw, passing through the web into the block. Spacer blocks are not used in a house.

Edge strips.—The edge strips, E, were yellow poplar, 14 ft $5^{15}/_{16}$ in. long, $^{7}/_{8}$ by 2 in., S2S, and were placed along the edges of the specimen to provide continuous support for the wallboard during nailing and when the specimens were handled. Each edge strip was fastened to the spacers by two 7d cement-coated common nails.

Before testing the roof specimen, the strips were sawed through between adjacent blocks and therefore had no appreciable effect on the structural properties of the specimen.

Edge strips are not used in a house.

Headers.—The headers, F, were sheet-steel channels, No. 20 U. S. Std. Gage (0.0368 in. thick), 4 ft $1^{15}/_{16}$ in. long, $6^{5}/_{32}$ in. wide, and 2 in. deep. The upper flange of each header was fastened to the webs of the panels by four $^{3}/_{4}$-in. No. 8 self-tapping screws, equally spaced, the screws at the edges entering spacer blocks. The lower flange was fastened by seven $1^{1}/_{4}$-in. No. 8 self-tapping screws, one into each edge strip and one through each nailing strip and through the flange of a panel back of the nailing strip.

Headers of this type are not used in a house.

Insulating board.—The insulating board, G, was 1 in. thick, and consisted of four pieces 4 ft 2 in. wide, three 4 ft 0 in. long and one 2 ft 6 in. long, laid transversely to the panels, the shorter piece being at one end of the specimen. The board was fastened to the roof deck (the upper surface of the webs of the panels) by asphalt 30 lb/100 ft^2, applied hot by mopping.

Roofing.—The roofing, H, was three-ply built-up asphalt-saturated felt, laid over the insulating board. Each strip of felt, 36 in. wide, was laid longitudinally of the specimen. The strips overlapped 25 in. Hot asphalt, temperature not over 400° F, was applied to the surface of the insulating board, to each strip of felt as it was laid, and finally to the upper surface of the built-up roof.

The amount of asphalt on the insulating board was 40 lb/100 ft^2, between the strips of felt 25/100 ft^2, and 40 lb/100 ft^2 on the built-up roofing.

Gypsum wallboard.—The gypsum wallboard, I, was $^{1}/_{2}$ in. thick and consisted of four pieces 4 ft 2 in. wide, three of them 4 ft 0 in. long and one piece 2 ft 6 in. long, the shorter piece being at one end of the specimen. The wallboard was fastened transversely to the roof panels by a row of 1-in. plasterboard nails, four into each nailing strip and edge strip through the longer pieces and three into each strip through the shorter piece. The joints in the wallboard were neither calked nor reinforced.

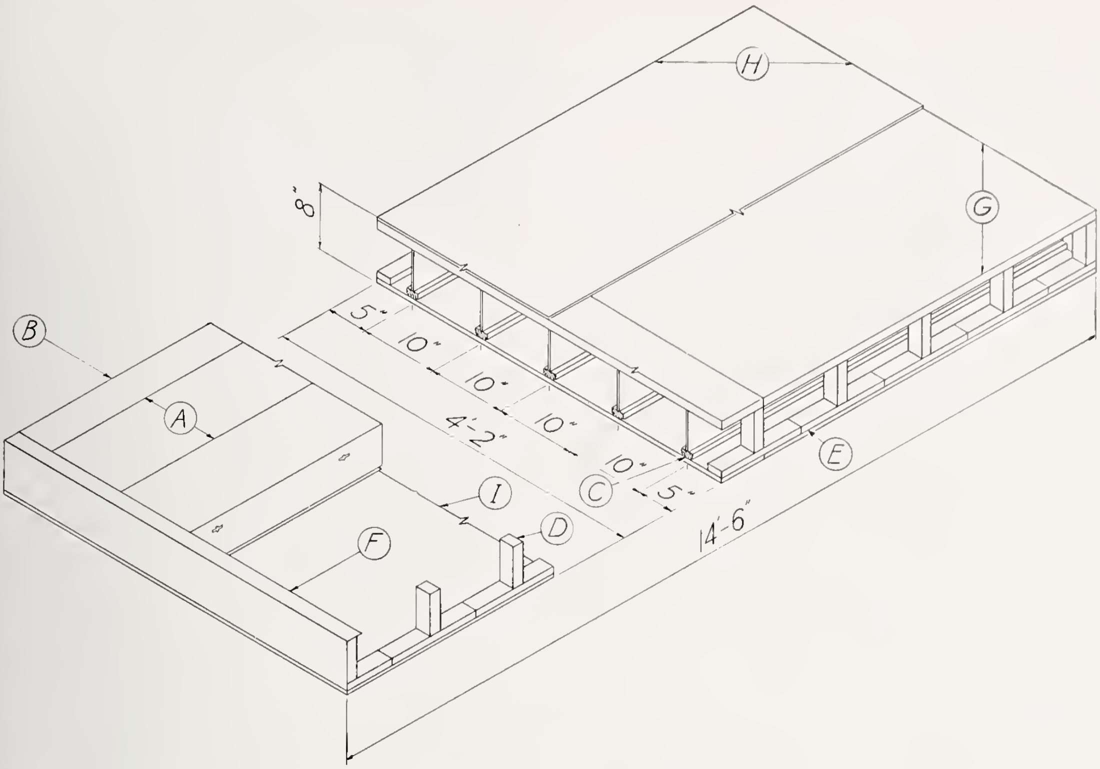


FIGURE 25.—*Roof specimen CS.*

A, full-width roof panels; *B*, half-width roof panels; *C*, nailing strips; *D*, spacer blocks; *E*, edge strips; *F*, headers; *G*, insulating board; *H*, roofing; *I*, gypsum wallboard.

FIGURE 26.—*Splice channel for roof panels.*

Paint.—The entire surface of each piece of steel was covered in the shop with one coat of primer, applied by spraying, and then baked 1 hour at 200° F.

2. Transverse Load

Roof specimen *CS–T1* under transverse load is shown in figure 27. The results for roof specimens *CS–T1*, *T2*, and *T3* are presented in table 10 and in figure 28.

Table 10.—*Structural properties of roof CS*

[Weight, 11.9 lb/ft²]

Transverse load [a]		Concentrated load	
Specimen	Maximum load	Specimen	Maximum load
	lb/ft²		*lb*
T1	170	*P1*	[b] 1,000
T2	172	*P2*	[b] 1,000
T3	150	*P3*	[b] 1,000
Average	164	Average	[b] 1,000

[a] Span 14 ft 0 in.
[b] Specimen did not fail

The speed of the movable head of the testing machine was adjusted to 0.29 in./min.

Under the maximum load on each specimen the webs and flanges of all the panels buckled between the loading rollers, but not in the splice. The wallboard on the lower face was undamaged.

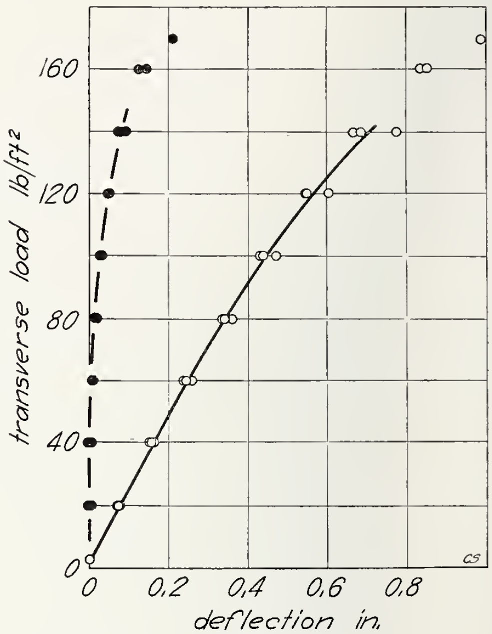


Figure 28.—*Transverse load on roof CS.*

Load-deflection (open circles) and load-set (solid circles) results for specimens *CS–T1*, *T2*, and *T3* on the span 14 ft 0 in.

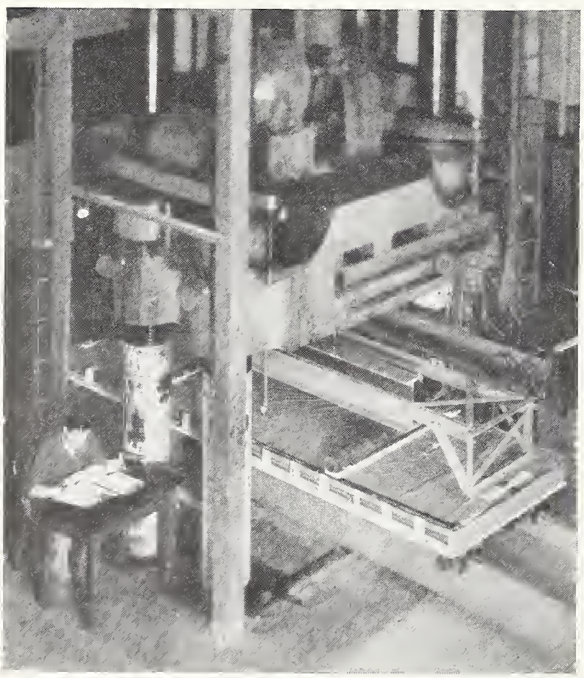


Figure 27.—*Roof specimen CS–T1 under tranverse load.*

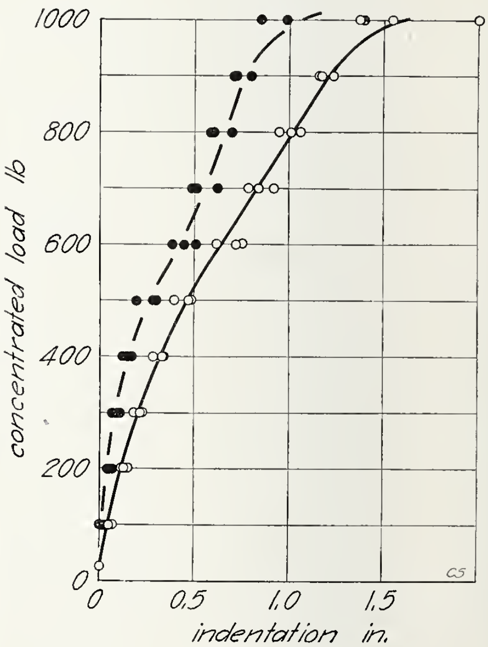
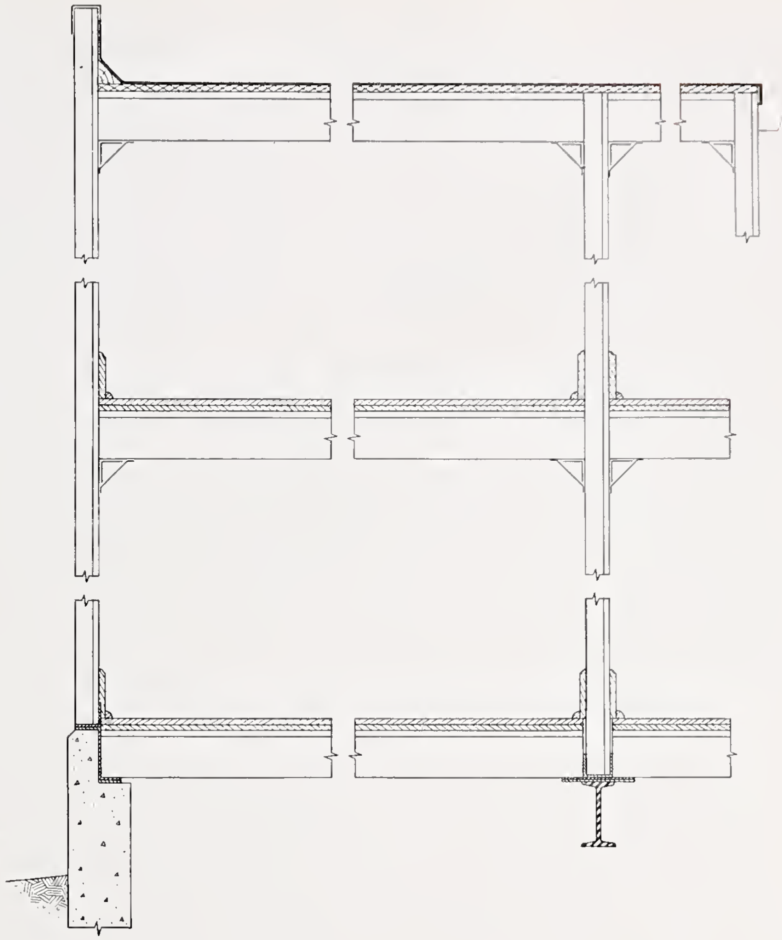


Figure 29.—*Concentrated load on roof CS.*

Load-indentation (open circles) and load-set (solid circles) results for specimens *CS–P1*, *P2*, and *P3*.

FIGURE 30—*Typical details of "Scot-Bilt" construction for houses.*



3. Concentrated Load

Results for roof specimens *CS–P1*, *P2*, and *P3* under concentrated load are shown in table 10 and in figure 29.

The loads were applied to the upper face on the asphalt roofing midway between the flanges of a panel and about 1½ ft from one end of the specimen. To obtain reproducible results each load was applied for 30 sec before reading the micrometers, and the set readings were taken 30 sec after release of the load.

The disk punched through the outer covering of asphalt and insulating board on each specimen. After a load of 1,000 lb had been applied to specimens *CS–P1*, *P2*, and *P3*, the sets were 0.98, 1.39, and 0.84 in., respectively, and no other effect was observed.

VIII. ADDITIONAL COMMENTS BY SPONSOR

Thirteen commercial buildings and one dwelling have been constructed of "Scot-Bilt" prefabricated units. Either mineral wool or reflecting metal sheets were used as thermal insulation.

Typical details of a house of this construction are shown in figure 30. Floor panels are not required if the floors are concrete. If there is no basement, a reinforced concrete slab serves as both foundation and first floor. The roof in all cases is of the flat type and is supported by 3- by 3-in. shelf angles screwed to the wall and partition panels. The wall panels extend above the roof on all sides except one, which is left open for run-off. On

the closed sides the roofing extends up along the inside of the wall panels and is overlapped by the continuous sheet-steel coping, No. 18 U. S. Std. Gage, which covers the tops of the wall panels. On the open side the roofing is extended down into a sheet-metal hanging gutter.

Both floor and roof panels may be erected with the flanges either up or down. If wallboard or plaster is used for ceiling finish, the flanges are turned down.

The interior wall finish consists of sheet-steel panels, wallboard, or plaster. Wallboard or lath is nailed to the wood strips over waterproof paper.

Load-bearing partitions are assembled from prefabricated sheet-steel wall panels. Non-load-bearing partitions consist of full-size prefabricated sheet-steel units. Pipes, ducts, and conduits are placed in the cavities of walls, floors, and partitions.

Chimneys are of brick with tile flue linings. Two-story buildings can be constructed by splicing the wall panels and supporting the second-story floor on shelf angles in the same manner as the roof.

The descriptions and drawings of the specimens were prepared by E. J. Schell, G. W. Shaw, and T. J. Hanley of the Building Practice and Specifications Section of this Bureau, under the supervision of V. B. Phelan.

The structural properties were determined by the Engineering Mechanics Section, under the supervision of H. L. Whittemore and A. H. Stang, with the assistance of the following members of the professional staff: F. Cardile, H. Dollar, M. Dubin, A. H. Easton, A. S. Endler, A. B. Lanham, A. J. Sussman, and L. R. Sweetman.

WASHINGTON, December 2, 1939.

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